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Characterization of iron and cobalt based catalysts after aquathermolysis processes by mössbauer spectroscopy

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Abstract

© SGEM2018. Heavy crude oils are extracted mostly by thermal recovery methods which reduce viscosity of heavy oil due to destruction of associative bonds in a complex oil fluid. In a number of articles, it is proved that at a temperature of more than 200-250° C there is also a certain chemical transformation of hydrocarbons, primarily containing hetero-elements. The use of finely-dispersed catalysts, injected directly into the oil-bearing formation, allows to intensify the processes of destructive hydrogenation of asphaltenes and resins during steam-heating treatment. The efficiency of various catalysts based on transition metals for the reactions of low-temperature cracking, hydrolysis and hydrogenolysis are well known. However, there is no clear understanding of the relationship between the nature of the catalyst and the activity of the transformation of asphalt-resinous compounds in reservoir conditions. The formation of the active form of the catalyst from the oil-soluble precursor has been studied to a small extent. In the work, samples of catalysts, extracted from the oil after laboratory modeling of aquathermolysis, were investigated. The precursors of the catalysts are iron and cobalt carboxylates.57 Fe Mössbauer absorption spectroscopy studies have been performed in zero magnetic field at room temperature to characterize the phase composition of the resulting mixed oxides. Mössbauer spectrum representing a spectrum characteristic of CoFe2O4 cobalt ferrite with spinel structure. At room temperature, a clear magnetic pattern is observed with no singlet or doublet contribution. The highest velocity peak shows a clear assymetry that strongly suggests that, at least, it involves two different components. An analysis of the Mössbauer spectra made it possible to estimate the population of cationic positions in iron-cobalt spinel and Co:Fe ratio. Proportion of the nanosized ferrite was evaluated from Mössbauer measurements at low temperatures. Relation of nature and state of the catalytically active metal and the transformation of asphalt-resinous compounds in reservoir conditions is also discussed.

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Keywords

Aquathermolysis, Catalyst, Mössbauer spectroscopy

References

[1] Huang S., Huang Q., Liu H., Cheng L., Fan Z., Zhao L. A modified model for aquathermolysis and its application in numerical simulation, Fuel, vol. 207, pp 568– 578, 2017.

[2] Kayukova G.P., Mikhailova A.M., Feoktistov D. A., Morozov V.P., Vakhin A.V. Conversion of the Organic Matter of Domanic Shale and Permian bituminous Rocks in Hydrothermal Catalytic processes, Energy and Fuels, vol. 31, issue 8, pp 7789-7799, 2017.

[3] Khalil M., Lee R. L., Liu N. Hematite nanoparticles in aquathermolysis: A desulfurization study of thiophene, Fuel, vol. 145, pp 214–220, 2015.

[4] Salih I. Sh. S., Mukhamatdinov I. I., Garifullina E. I., Vakhin A. V. Study of Fractional Composition of Asphaltenes in Hydrocarbon Material, Chemistry and Technology of Fuels and Oils, vol. 54, issue 1, pp 44-50, 2018.

[5] Tumanyan B.P., Petrukhina N.N., Kayukova G.P., Nurgaliev D.K., Foss L.E., Romanov G.V. Aquathermolysis of crude oils and natural bitumen: Chemistry, catalysts and prospects for industrial implementation, Russian Chemical Reviews, vol. 84, issue 11, pp 1145-1175, 2015.

[6] Weissman J.G., Kessler R.V. Downhole heavy crude oil hydroprocessing, Applied Catalysis A: General, vol. 140, pp 1–16, 1996.

[7] Maity S.K., Ancheyta J., Marroquín G. Catalytic Aquathermolysis Used for Viscosity Reduction of Heavy Crude Oils: A Review, Energy Fuels, vol. 24, issue 5, pp 2809−2816, 2010.

[8] Muraza O., Galadima A. Aquathermolysis of heavy oil: A review and perspective on catalyst development, Fuel, vol. 157, pp 219–231, 2015.

[9] Panariti N., Del Bianco A., Del Piero G. et al. Petroleum Residue Upgrading with Dispersed Catalysts. Part 1. Catalysts Activity and Selectivity, Applied Catalysis A: General, vol. 204, pp 203–213, 2000.

[10] Matsnev M. E., Rusakov V. S. Mössbauer Spectroscopy in Materials Science-2012: Proceedings of the International Conference MSMS-12, American Institute of Physics Conference Series, vol. 1489, pp. 178, 2012.

[11] De Grave E., Vandenberghe R.E., Dauwe C. ILEEMS: Methodology and Applications to Iron Oxides, Hyperfine Interactions, V. 161, pp. 147–160, 2005.

[12] Sawatzky G. A., van der Woude F. and Morrish A. H. Mössbauer study of several ferrimagnetic spinels, Phys. Rev., 187, pp. 747–757, 1969.

[13] Lyubutin I. S., Gervits N. E., Starchikov S. S. et al. Magnetic and Mössbauer spectroscopy studies of hollow microcapsules made of silica-coated CoFeO nanoparticles, Smart Mater. Struct., 25, pp. 015022-015033, 2016

[14] Sawatzky G. A., van der Woude F. Morrish A. H. Cation distributions in octahedral and tetrahedral sites of the ferrimagnetic spinel CoFeO, J. Appl. Phys., 39, pp.1204-1206,1968.

[15] Sitnov S.A., Mukhamatdinov I.I., Vakhin A. V., Ivanova A.G., Voronina E. V. Composition of aquathermolysis catalysts forming in situ from oil-soluble catalyst precursor mixtures, Journal of Petroleum Science and Engineering, vol. 169, pp. 44-50, 2018.

[16] Ivanova A. G., Vakhin A. V., Voronina E. V., Pyataev A. V., Nurgaliev D. K., Sitnov S. A., Mössbauer study of products of the thermocatalytic treatment of kerogen-containing rocks, Bulletin of the Russian Academy of Sciences. Physics, vol.81, issue 7, pp 817-821, 2017.